VOLUME CONTROLLER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a volume controller for balancing the sound volume between a front speaker which is located at the front of a vehicle and a rear speaker which is located at the rear of the vehicle.

2. Description of the Related Art

Traditionally, an audio device has been widely used which is provided with four speakers on the left and right sides at the front and the rear within a vehicle, respectively in order to cause a driver/passenger to hear the signal reproduced from a broadcast, CD, DVD, etc.

Such an in-vehicle audio device can regulate the volume balance in a to-and-fro direction. In this case, as shown in Fig. 3, where a balancing point is moved from the center to the front side by an fade input from a fader inputting unit the volume from the front speaker does not vary whereas the volume from the rear speaker decreases with the fade input. If the balancing point is moved from the center toward the rear side, the volume from the rear speaker does not vary whereas the volume from the front speaker decreases with the fader input.

The volume balancing regulation having such a characteristic has the following disadvantage. Where a

passenger who sits on the rear seat of a one-box car enjoys, a movie using a DVD player, which is now prevailing, using a rear speaker as a main speaker, he or she balances the volume from a center position to the rear side. However, actually, the volume decreases only at the front. It lacks the spreading toward the front at the listening point, and the volume within an entire room varies (decreases). This makes it difficult to form a sound field with a sense of realism.

SUMMARY OF THE INVENTION

An object of this invention is to provide a volume controller capable of regulating the balance in a volume level between a front side and a rear side without decreasing the volume of an entire passenger room.

In order to attain the above object, in accordance with this invention, there is provided a volume controller for controlling volume balance between a front speaker and a rear speaker located within a vehicle, comprising:

a fade volume computing unit for computing an amplifying factor k1 of an input signal for providing an increased volume at the rear or front speaker by the volume at a prescribed position within the vehicle which is equal to an decreased volume in the front or rear speaker when a signal supplied to the front or rear speaker is attenuated by an attenuating factor K1; and

a control unit for multiplying the signal supplied to the rear or front speaker by k1 when a signal supplied to the

front or rear speaker is attenuated by K1.

In the volume controller, preferably, the prescribed position is located at a center of a front seat, at a center of a rear seat, or a center between the front seat and the rear seat.

In the volume controller, preferably, attenuations when acoustic waves from the front speaker and rear speaker are propagated to the prescribed position are previously recorded, and on the basis of the attenuations, the increased and decreased volumes at the front or rear speaker are computed.

In the volume controller, preferably, the attenuations are computed on the basis of an input indicative of a relationship between the prescribed position and positions where the front and rear speaker are located.

In the volume controller, preferably, the increased volumes of the front or rear speaker and of the rear or front speaker are computed on an adjustment value in a level adjusting means to be connected to the front speaker and the rear speaker.

In accordance with this invention, where the volume balance between the front and the rear speakers is adjusted, when the volume at the front or rear speaker decreases, the volume at the rear or front speaker is increased so that the volume at a prescribed position in a passenger room is equal to that before the balance is adjusted. For this reason, after the volume balance between the front and rear speaker has been carried out, the sound field with a sense of realism can be

formed.

The above and other objects and features of the invention will be more apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an arrangement view of the volume controller according to an embodiment of this invention;

Fig. 2 is a view for explaining the operation of the embodiment; and

Fig. 3 is a view for explaining a conventional volume controller.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now referring to Fig. 1, an explanation will be given of an embodiment of a volume controller according to this invention.

Fig. 1 is an arrangement view of an embodiment of a volume controller according to this invention.

As seen from Fig. 1, a front seat 2 and a rear seat 3 are located at the front and at the rear thereof within a vehicle 1, respectively.

On the front left side and front right side of the vehicle 1, a front left side speaker (SFL)4 and a front right side speaker (SFR)5 are arranged, and on the rear left side and the rear right side of the vehicle 1, a rear left speaker (SRL)6 and

a rear right speaker (SRR)7 are arranged.

Attenuators 8TFL, 8TFR, 8TRL and 8TRR are provided so as to correspond to the (SFL)4, (SFR)5, (SRL)6 and (SRR)7, respectively. An R signal to be reproduced is supplied to the attenuators 8TFR and 8TRR, and an L signal to be reproduced is supplied to the attenuators 8TRL and 8TRR.

The R and L signals, which have been level-regulated by the attenuators 8TFR, are amplified by amplifiers 9AFR, 9ARR, and 9AFL and 9ARL by a predetermined amount. The R and L signals are reproduced by the speakers (SFR)5, (SRR)7, and (SFL)4, (SRL)6.

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In Fig. 1, reference numeral 10 denotes a preset attenuation value recording unit for recording a preset attenuation value described later, 11 a loss recording unit; and 12 a fade volume computing unit for computing a signal amplifying factor (described later) on the basis of the preset value recorded on the preset attenuation value recording unit 10, an attenuated amount recorded on the loss recording unit 11 and a movement ("fade")of a balancing point from the center to the front or rear side inputted form the fade input unit. Reference numeral 13 denotes an entire volume input unit for controlling the volume of the signals reproduced by the front left speaker (SFL)4, front right speaker (SFR)5, rear left speaker (SRL)6 and rear right speaker (SRR)7. Reference numeral 14 denotes an individual volume input unit for individually controlling the volume of the signal reproduced

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by each of the front left speaker (SFL)4, front right speaker (SFR)5, rear left speaker (SRL)6 and rear right speaker (SRR) 7. Reference numeral 15 denotes the fade input unit for setting the above "fade" in the conventional volume controller as shown in Fig. 3. Reference numeral 16 denotes a control unit. Reference numeral 17 denotes an interface (I/O) for supplying various values to the attenuators 8TFL, 8TFR, 8TRL and 8TRR under the control by a processor (CPU) 18. Reference numeral 18 denotes the processor for executing the control processing for the preset value recording unit 10, loss recording unit 11, fade volume computing unit 12, entire volume input unit 13, individual volume input unit 14, fade input unit 15 and control unit 16.

As shown in Fig. 2, with a central point P between the the front seat 2 and the rear seat 3, the loss recording unit 11 previously records an attenuated amount L_1 of an acoustic wave produced from the front left speaker (SFL) 4 or the front right speaker (SFR) 5 while it reaches the central point P, and an attenuated amount L_2 of an acoustic wave produced from the rear left speaker (SRL) 6 or the rear right speaker (SRR) 7 while it reaches the central point P.

In recording, with attenuated amounts for distances which have been acquired experimentally being recorded, the loss recording unit 11 may compute the attenuated amounts L1 and L2 by inputting the distances to the central point P.

The distances to the central point P may be computed from

the distance D1 between the left and right speakers, the distance D2 between the front and rear speakers, distance D3 between the front speakers and the front seat P1, and distance D4 between the front seat P1 and rear seat P2.

An explanation will be given of the operation of the volume controller according to this invention.

Now it is assumed that the volume produced from the speaker is proportional to the level of the signal supplied thereto.

Assuming that the R signal and L signal supplied to the volume controller according to this invention have equal signal levels and the amplifiers 9AFR, 9AFL, 9ARL and 9ARR connected to the speakers provide equal gains, the volume of the sound produced from the front left speaker (SFL) 4, front right speaker (SFR) 5, rear left speaker (SRL) 6 and rear right speaker (SRR) 7 is proportional to the attenuating amount in the attenuators 8TFL, 8TFR, 8TRL and 8TRR.

Assuming that the attenuations in the attenuators 8TFL, 8TFR, 8TRL and 8TRR are TFL, TFR, TRL and TRR, respectively, if an increment or decrement of a constant K is input from the entire volume unit 13,

$$\begin{aligned} TFL &= K \\ TFR &= K \\ TRL &= K \\ TRR &= K \end{aligned} \quad \cdots \quad (1)$$

Therefore, the respective attenuators provide the increment or decrement of the same value K.

Where the individual volume input unit 14 performs the volume adjustment for each speaker input unit 14 to supply the attenuating amounts kFL, kFR, kRL and kRR to the attenuators 8TFL, 8TFR, 8TRL and 8TRR,

$$TFL = K + k_{FL}$$
$$TFR = K + k_{FR}$$
$$TRL = K + k_{RL}$$
$$TRR = K + k_{RR} \quad \ldots \quad (2)$$

The attenuations TFL, TFR, TRL and TRR are recorded in the preset value recording unit 10.

Assuming that the input from the fade input unit 15 is a "center" value (attenuating factor $K_F = 1$), the entire volume P at the position P in Fig. 2 is represented by

$$P = SV(TFL + TFR)L_1 + SV(TRL + TRR)L_2 \quad \ldots \quad (3)$$

where SV represents a product of an input signal (L signal, R signal) and the gain of the amplifier 9.

In the following explanation, the entire volume P in Equation (3) is normalized by SV, and the normalized value is represented by P. Namely,

$$P = (TFL + TFR)L_1 \text{ and } (TRL + TRR)L_2 \quad \ldots \quad (4)$$

If a movement of a balancing point from the center to the rear side (the signal for the front speaker is attenuated by the attenuating factor K_F ($K_F > 1.0$)) is inputted by the fade input unit 15, TFL and TFR are represented by

$$TFL = KF(K + k_{FL})$$
$$TFR = KF(K + k_{FR}) \quad \ldots \quad (5)$$

The volume P_F from the front speakers at the point P is a sum of TFL and TFR in Equation (5). Namely,

$$P_F = K_F \{(K + k_{FL}) + (K + k_{FR})\}L_1 \quad \ldots \quad (6)$$

In this invention, where the balancing point is moved to the rear side by the fade input unit, when the volume from the front speaker becomes P_F expressed by Equation (6), the volume P_R from the rear speaker is increased so that the volume at point P is equal to the volume before the balancing point moves.

Namely,

$$P_F + P_R = P \quad \ldots \quad (7)$$

Assuming that the signal amplification factor kR for the rear speaker (k_R = 1.0 – 0.0),

$$P_R = k_R(TRL + TRR)L_2$$

$$= k_R\{(K + K_{RL}) + (K + k_{RR})\}L_2 \quad \ldots \quad (8)$$

Substituting Equations (4), (6) and (8) into Equation (7),

$$K_F = \{(K + k_{FL}) + (K + k_{FR})\}L_1 + k_R\{(K + k_{RL}) + (K + k_{RR})\}L_2$$

$$= \{(K + k_{FL}) + (K + k_{FR})\}L_1 + \{(K + k_{RL}) + (K + k_{RR})\}L_2 \quad \ldots \quad (9)$$

Therefore, k_R is acquired from Equation (9),

$$k_R = 1 + (1 - K_F)\{(K + k_{FL}) + (K + k_{FR})L_1$$

$$/\{(K + k_{FL}) + (K + k_{RR})L_2 \quad \ldots \quad (10)$$

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In Equation (10), $(K + k_{FL})$, $(K + k_{FR})$, $(K + k_{FL})$ and $(K + k_{RR})$, as explained in connection with Equation (2), have been recorded as TFT, TFR, TRL and TRR in the preset value recording

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unit 10. L_1 and L_2 have been recorded in the loss recording unit 11. If the movement of a balancing point from the center to the rear side (the signal for the front speaker is attenuated by the attenuating factor K_F ($K_F > 1.0$))is supplied from the fade input unit 15, the face volume computing unit 12 read the data from the preset value recording unit 10 and the loss recording unit 11 to execute the operation of Equation (10), thereby computing k_R.

The control unit 16 multiplies the attenuated amount in the attenuators 8TRL and 8TRR by k_R .

Upon completion of the operation of computing the fade volume, the control unit 16 records the K_F-times values of the attenuators 8TFL and 8TFR and the K_R-times values of the attenuators 8TRL and 8TRR in the preset value recording unit 10 to deal with a next fade input. The preset values are set at the recorded attenuations in the attenuator 8TFR, 8TFL, 8TRL and 8TRR.

On the other hand, if a movement of the balancing point from the center to the front side is supplied from the fade input unit 15 (the signal for the rear speaker is K_R attenuated ($K_R > 1.0$)), the attenuations in the attenuators 8TRL and 8TRR are multiplied by K_R.

Assuming that the signal amplification factor k_F for the rear speaker ($k_F = 1.0 - 0.0$), the fade volume computing unit 12 computes k_F from the following Equation

$$k_F = 1 + (1 - K_R)\{(K + k_{RL}) + (K + k_{RR})L_2$$

$$/\{(K + k_{FL}) + (K + k_{FR})L_1 \quad \ldots \quad (11)$$

Upon completion of computing the fade volume, the K_F-times and K_R-times attenuations are recorded in the preset value recording unit 10 to deal with a next fade input. The preset values are set at the recorded attenuations in the attenuator 8TFR, 8TFL, 8TRL and 8TRR.

In the embodiment described above, although the center point P was located between the front seat 2 and the rear seat 3, as seen from Fig. 2, it may be a center point P1 of the front seat 2 or center point P2 of the rear seat 3. The center point may be exchanged among P, P1 and P2.